BRIEF COMMUNICATION

USE OF GROWTH RINGS TO DETERMINE AGE IN THE FRESHWATER TORTOISE *CHELODINA LONGICOLLIS*: A CAUTIONARY NOTE

Counts of laminal growth rings visible on the shells of freshwater North American testudines have been used to determine the ages of individual animals[1,2]. Periods of brumation coincide with the formation of deep grooves in the epidermis of the shell[3], which are initially hidden in the interlaminal seams. They become visible after spring growth commences forming a ridge delineating the outer edge of the groove[4] and the spreading of the interlaminal seams brings the grooves to the surface. For north temperate species[5], a "year" can be added to the known age of individuals when the groove becomes visible[6]. The grooves are generally known as growth rings[5,7].

Coincident with the recommencement of growth is the formation of a new, deeper layer of epidermis[8]. The margin of the plate of scute epidermis laid down in the previous season's growth is delineated by the growth ring formed at the commencement of the next season of growth[9]. Old layers of epidermis may be retained in terrestrial testudines[8], but in aquatic species they are usually shed, either as single [8] or, eventually, multiple layers[9]. Repeated scute ecdysis causes growth rings to weaken then disappear[7].

Temporary cessation of growth during the growing season may result in the formation in many species of shallow grooves, termed minor growth rings[8,9]. However, minor growth rings are not associated with the formation of a new layer of epidermis[8,9].

Measurement of the gaps between major growth rings, together with counts of their number, have been used to determine growth rates in any particular past year[7,10].

Determination of age based on counts of growth rings requires that the number of growth rings produced by a sample of the population over a long period of time be known, and the only satisfactory means of determining the periodicity of growth ring production is to conduct capture-recapture exercises[7] over several years. Usually, it is assumed that only one major growth ring is formed annually[11], and for north temperate species this assumption is normally valid[5]. However, the assumption that only one growth ring is formed annually by a particular population of a species is not always verified.

The technique of aging has been applied to an Australian species (*Pseudemydura umbrina*) by Burbidge[12]. The technique of determining growth rates has been applied to *Chelodina longicollis* by Parmenter[13] and, with reservations, to *C. longicollis* and two other Australian species (*Emydura macquarii* and *Chelodina expansa*) by Chessman[14].

Although verification of the annual deposition of growth rings was undertaken by Burbidge for the populations of *Pseudemydura umbrina*[15], there is no clear indication that the periodicity of deposition of growth rings has been determined for populations of *C. longicollis*. Parmenter developed an argument inferring that annual deposition of growth rings occurred in *C. longicollis*, because the species ceases to grow during annual brumation; but there is no evidence that he verified the conclusion[13]. Chessman initially assumed that growth rings were deposited annually, but on comparison with growth rates, as determined on recapture, he concluded that the deposition of growth rings may be affected by growth rate, and that major growth rings may have been confused with minor rings[14].

Parmenter extrapolated from conclusions relevant to North American species to *C. longicollis*; but North American winters are longer and more severe than winters in the range of *C. longicollis*. Daily mean temperatures in the mid west of the United States differ by about 25°C between mid Summer and mid Winter[16] (Table 1), but the difference is only 14°C at Armidale, near where Parmenter undertook his field study. The activity period for *Kinosternon flavescens* in Oklahoma is 140 days[2], but Parmenter reports an activity period of 250–280 days for *C. longicollis*[13]. Without marked annual temperature cycles the growth of turtle scales is often even and free of interruptions[19]. On the coastal plain of the Gulf of

TABLE 1. *Daily Mean Temperatures at Meteorological Stations Near Testudine Study Sites*

STATION	SPECIES	DAILY MEAN °C MID-SUMMER	TEMPERATURE °C MID-WINTER
Tulsa, Ok, U.S.A.	*Kinosternon flavescens*[2]	27.9	2.9
Lansing, Mi, U.S.A.	*Chrysemys picta*[4]	22.1	−4.3
Omaha, Ne, U.S.A.	*Chelydra serpentina*[6]	25.3	−5.4
St Louis, Mi, U.S.A.	*Pseudemys scripta*[7]	26.4	0.1
Kansas City, Ks, U.S.A.	*Terrapene ornata*[5]	27.2	−0.7
Phoenix, Az, U.S.A.	*Kinosternon sonoriense*[10]	32.9	10.4
New Orleans, La, U.S.A	*Sternothaerus carinatus*[17]	28.4	13.3
Colon, Panama	*Pseudemys scripta*[9]	26.6	25.8
Armidale, N.S.W., Aust.	*Chelodina longicollis*[13]	20.4	6.6
Melbourne, Vic., Aust.	*Chelodina longicollis*[14]	19.9	9.6
Mildura, Vic., Aust.	*Chelodina longicollis*[14]	24.1	10.1
Adelaide, S.A., Aust.	*Chelodina longicollis*[18]	22.6	11.2

Source of climatic data — "World Survey of Climatology", ed. H.E. Landsberg, Elsevier, Amsterdam, (1971).

References are to studies undertaken in vicinity of stations.

Mexico, the winters are more moderate, with daily mean temperature differences of about 13°C[16]. On the plain the growth rings were not as clear in *Sternotherus odoratus* as they were in emydid turtles, and the need for caution in their unverified use for age determination was emphasised[17].

Further south the climate is even more equable (Table 1). Colon, Panama, is close to the study sites of Moll & Legler[9], yet they noted the formation of up to four major growth rings in a single year in a population of *Pseudemys scripta*. Their conclusion was that growth rings are not necessarily related to temperature variation, and attributed the formation of growth rings in this population to cessation of feeding during periods of flooding[4].

Cagle stated that any interruption in the supply of food or in the ability of the individual to utilise food may result in the formation of a major growth ring[7], and Chessman reports minimal stomach contents in one population of *C. longicollis* in both mid-Summer and Winter[14], perhaps because *Duplinia carinata* was the major food item in that population, and *D. carinata* can exhibit a diphasic annual population cycle[20]. Hence the potential exists for multiple annual production of growth rings by populations of *C. longicollis*.

Here I record the number of growth rings formed in an individual *C. longicollis* over a known period. The animal was caught twice during a study on a population of this species which inhabits a number of ponds on the campus of Roseworthy Agricultural College, 45 km N of Adelaide.

The animal was first captured on 29.Jan.80. It was numbered using a pattern of drill holes in its marginal scutes, a technique which often leads to retention of old epidermal layers after scute ecdysis. The drill holes may heal with a hollow bridge of epidermal tissue connecting the shed epidermal layers of the upper and lower surfaces of the scutes, like a rivet through the hole. The subsequent capture was on 25.Nov.83.

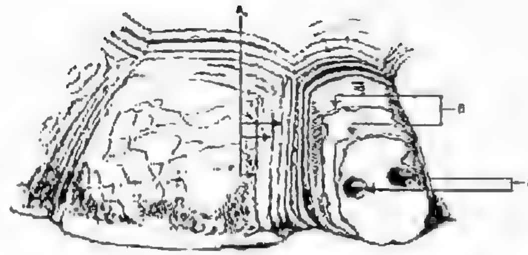

Fig. 1 Anteiror view of nuchal and first right marginal scutes. A, growth ring on bare scute; B, growth ring on retained epidermal layer; C, drill hole.

Six old epidermal layers were retained on both of the drilled scutes, but none on the other scutes. There was one visible growth ring on each of the retained epidermal layers, which corresponded precisely with the margin of the next most superficial retained epidermal layer (Fig. 1). Four growth rings which occurred towards the periphery of the bare scutes, corresponded in position to the four largest growth rings imprinted on the deeper retained epidermal layers on the drilled scutes. It was concluded that these growth rings were of the major type. Six had been produced in three years and ten months.

I contend that it is not valid to assume that one growth ring is produced in each year by *C. longicollis*: verification of the periodicity of production of growth rings is required for any population under study.

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